Diaprepes Root Weevil: Recent Advances at the U.S. Horticultural Research Laboratory, Fort Pierce

By Richard T. Mayer, Wayne B. Hunter, Stephen L. Lapointe, C. L. McKenzie, R. Shatters, J. Shapiro, Hamed Doostdar, and A. A. Weathersbee III*

***Part I:** The following is Part I of a two-part series. Part II will appear in the August 2001 issue of* C&VM.

The Diaprepes root weevil; *(Diaprepes abbreviatus* L.) is the most serious pest problem facing citrus growers in Florida with damage estimates projected at $1.5 billion (20 years) to the Florida citrus industry alone. The USDA's Agricultural Research Service (ARS) has maintained a research program on the Diaprepes root weevil - (DRW) since it's discovery in Apopka, Fla. in the early 1960's. The ARS research program is currently located at the U. S. Horticultural Research Laboratory (USHRL) at Ft. Pierce, Fla. (formerly at Orlando, Fla.). Many new approaches for control of DRW have been initiated at the USHRL; these include biological control (entomopathogens), molecular biology, cultural practices, and biochemical and physiological methods. In addition, new information on the biology of the insect is being collected. This is a current report of research programs at the USHRL for the DRW.

Diaprepes abbreviatus (L.), is a major constraint to production of citrus and ornamentals in Florida and the Caribbean Basin. Since the discovery of this pest in the United States in the early 1960's, it has spread throughout peninsular Florida and has been reported in Texas. Larvae of DRW are a primary concern of Florida citrus and vegetable producers because of the difficulty of detecting and monitoring soil-inhabiting larvae in general, and the destructive habits of DRW larvae in particular. Larvae and adults are highly polyphagous, feeding on the roots and leaves, respectively, of many wild and cultivated plant species. Larvae pupate in the soil. When the callow adults emerge from the pupal case, they remain in the pupal chamber (subterranean location of the pupa) for several days to weeks (teneral period) until sclerotization of the cuticle is complete. Oviposition (egg laying commences at 3 to 7 days after adult emergence from the soil and will continue for several months since the adults are long-lived. A single female adult will lay thousands of eggs. There may be one or two DRW generations per year under Florida conditions.

Cultural factors also limit control options available to growers. The relatively low value per unit area of the citrus crop in Florida places economic constraints on control methods. Also, the high permeability of Florida's soils and elevated water tables make contamination of ground water with pesticides a risk. Moreover, soil treatments with pesticides would be difficult because there are no larvicides currently registered to control DRW. Applications of adulticides such as carbaryl are of questionable efficacy although some growers report success with coordinated area-wide aerial applications based on detection of peak adult emergence. The Florida Department of Agriculture and Consumer Services re-

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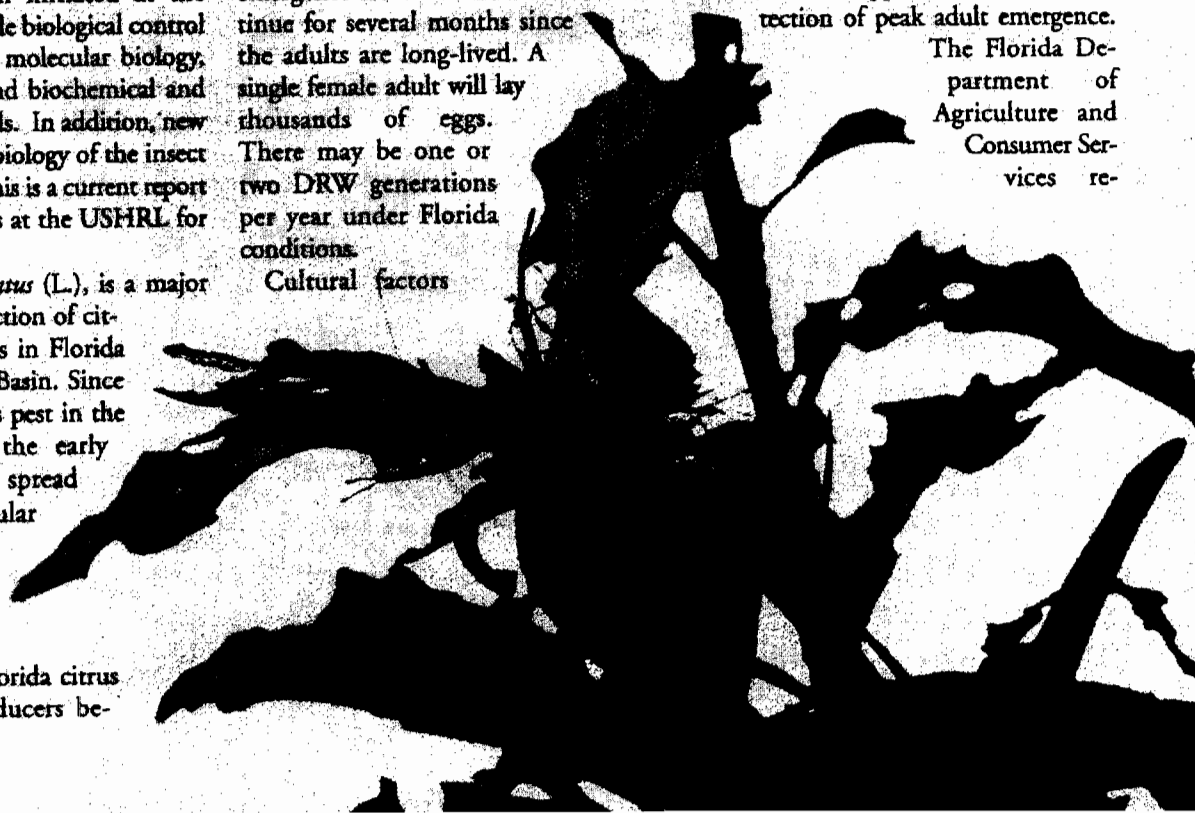

cently received a specific exemption under the provision of Section 18 of FIFRA for use of bifenthrin (formulated as Capture 2EC) for use as a chemical barrier to the movement of young (neonate) DRW larvae.

The ARS has placed a high priority on finding short- and long-term control options for DRW that are environmentally sound and economically viable. This article summarizes the major research areas currently underway at the U.S. Horticultural Research Laboratory at Ft. Pierce, Fla. and highlights some recent advances.

Basic Biology

Research priorities for DRW conducted by ARS identified key research needs related to this pest. A high priority was attached to gaining knowledge about the basic biology of the insect. Much of the basic biological knowledge available on DRW stems from the fact that USHRL developed standardized rearing procedures for DRW (Bill Schroeder, Ph.D. with later improvements by Steve Lapointe, Ph.D.); this has achievement has helped supply ample numbers of DRW at all growth stages to many different scientists. Karin Crosby supervises DRW rearing at USHRL.

Earlier, research by USHRL scientists in the Subtropical Insects Research Unit (SIRU) established that the major molting hormone for the DRW is a steroid (20-hydroxyecdysone). Insect molting is a major target for controlling insect pests.

More recently, Steve Lapointe completed an exhaustive study of the effects of moisture and temperature on developmental rates, pupation, and survival of immature stages of the weevil. The minimum temperature for egg development (functional lower developmental threshold) was calculated to be 12C and the upper limit for constant temperatures occurred between 30 and 32C. Growth of hatchling larvae increased exponentially with increasing temperature up to 30C. However, the growth rate of older larvae (>56 days old) was suppressed at 30C and mortality was higher than that of larvae reared at 22 or 26C.

The time required for development from hatchling larvae to pupation was 125 days at 26C. Pupal mortality was higher at 30C than at 22 or 26C. The total time required for a single generation from oviposition to adult emergence at 26C was estimated to be 154 days. Various aspects of DRW biology have not been adequately studied. Efforts to identify sex pheromones of this species have been unsuccessful. Pheromones are important tools for detection and monitoring many species of agricultural pests. A survey was initiated on the external morphology of DRW with an eye towards discovery of structures that could secrete substances that affect the behavior of the adult insect.

Research on the biochemistry and physiology of the DRW has been performed Richard Mayer, Ph.D., and Hamed Doostdar Ph.D., at USHRL. Information on chitin synthesis in larvae was obtained that included studies on compounds that might inhibit chitin formation. Chitin is a structural carbohydrate polymer that comprises the exoskeletons of insects and the peritrophic membrane (a protective lining) in larval and adult guts. Also, a unique larval gut endo-polygalacturonase (PG; digests pectins) was isolated and characterized. The DRW-PG is unique because it was the first animal PG that was inhibited by a grapefruit polygalacturonase inhibitor protein (PGIP); this offers an opportunity for controlling DRW either by application of inhibitors or breeding plants that have large amounts of effective PGIP's.

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External ducts discovered by Steve Lapointe and Wayne Hunter, Ph.D. are thought to produce waxy filamentous secretions that coat the elytra (front wings) of DRW. These substances may be contact pheromones or act as carriers or release platforms for more volatile compounds. Glands and associated structures on the elytra of teneral (newly emerged adults) and mature DRW were studied via scanning electron microscopy (SEM).

There were clear differences between teneral, callow, and fully mature adults. In citrus groves, teneral adults remain in the pupal chamber within the soil until sclerotization of the cuticle is complete or nearly so. Variations in the appearance of the elytra in DRW consists of varying patterns and coloration of scaled intervals between variable numbers of raised ridges devoid of scales. In addition to being thinner and lighter in color than fully mature adults, the elytra of teneral adults were devoid of waxy hydrocarbon secretions. External gland openings were observed at the base of each scale on teneral elytra and mature elytra (when washed with methylene chloride). SEM has documented the production of waxy hydrocarbons by these glands and their products have been partially characterized by gas chromatography and mass spectrometry.

Proof that the DRW has not been exhaustively studied comes from the fact that adults have mandibular incisors (see figure below) when they emerge from the pupal case. However, the adults usually lose the incisors either when they tunnel out of the earth or shortly thereafter. Dr. Allen Weathersbee found that loss of the mandibular incisors correlates with humidity, i.e., in high humidity environments the mandibular incisors remain on the adult longer. The purpose of the incisors is not known. Adult DRW can feed with the incisors intact and the feeding pattern on leaves is very different from that of adults without incisors; the difference is that the margin of feeding damage is wider in leaves fed on by adult DRW retaining the mandibular incisors. *CVM*

Richard T. Mayer, Wagne B. Hunter, Stephen L Lapointe, C.L. McKenqie, R. Shatters, Hamed Doostdar an A.A. Weathersbee III are located at USDA-ARS U.S. Horticultural Research Lab, Ft. Pierce, FL 561-462-5897. J. Shapiro is located at uSDA, Gainesville, FL.